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Docket No.: 09634/000L266-US0
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Letters Patent of:
Jun Ikeda et al.

Patent No.: 6,987,498

Issued: January 17, 2006

For: DISPLAY UNIT AND DISPLAY METHOD

REQUEST FOR CERTIFICATE OF CORRECTION
PURSUANT TO 37 CFR 1.323 AND PATENT OFFICE MISTAKE (37 CFR 1.322)

Attention: Certificate of Correction Branch
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Upon reviewing the above-identified patent, Patentee noted several patent office errors which should be corrected.

The following errors were not in the application as filed by applicant:

In the Application:

Column 1, Line 52, After "small" insert --.--.

Column 2, Line 41, After "problem" insert --,--.

Column 2, Line 45, After "problem" insert --,--.

Column 5, Line 55, Delete "stir" and insert -- still --.

Column 7, Line 55, After "nm" delete ",." and insert --.--.

Column 8, Line 32 (Approx.), Delete "12 bit-data" and insert --12-bit-data--.

Column 9, Line 22, Delete "ROB" and insert --RGB--.

Column 9, Line 33, Delete "I 1" and insert --11 --.

Enclosed please find marked up copies of the Specification.

The following errors were found in the application as filed by applicant. The errors now sought to be corrected are inadvertant typographical errors, the correction of which does not involve new matter or require reexamination.

Column 7, Line 11, Delete "the"and insert -- The --.

Transmitted herewith is a proposed Certificate of Correction effecting such amendment. Patentee respectfully solicits the granting of the requested Certificate of Correction.

The Commissioner is authorized to charge any deficiency of up to $300.00 or credit any excess in this fee to Deposti Account No. 04-0100. Enclosed please find a check for $100.00.

Dated: March 21, 2006

Respectfully submitted,

By______________________

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 6,987,498

APPLICATION NO. : 09/989,593

ISSUE DATE : January 17, 2006

INVENTOR(S) : Jun Ikeda et al.

It is certified that an error appears or errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Application:

Column 1, Line 52, After "small" insert --.--.

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MAR 29 2006

Japanese Unexamined Patent Publication No. Hei-6-138858 discloses a technique in which the error diffusion method is employed.

In these publications, multi-bit display data (for example, each RGB component has 8 bits, 6 bits or the like) is color-reduced to 12 bits (4,096 colors). Hereinafter, for convenience of explanation, an example where multi-bit data is color-reduced to 12 bits (4,096 colors) is cited. However, the present invention is also applicable to a case where another color reduction is carried out, as long as it does not deviate from the spirit of the invention.

In such publications, when performing the color reduction to 12 bits (4,096 colors), 4 bits are distributed to each RGB component, respectively. In addition, there are examples of an 8-bit color system provided as R:G:B = 3:3:2 (bits) and a 6-bit color system provided as R:G:B = 5:6:5 (bits). These ratios are based on the idea that it is satisfactory that the bit numbers are roughly uniformly allotted among the RGB. When the bit number is not completely uniformly assigned, 1 bit is merely reduced (8 bits) or increased (16 bits) at the most.

However, such distribution deviates from human visual performance, detailed reasons of which will be described later. As a result, the display quality is poor due to the G component being too small. Also, the amount of information is wasted due to the B component being too large.

In more detail, since the G component is too small, a sense of unevenness between adjacent pixels, a pseudo-outline may result. Since the B component is too large, the requisite amount of memory unnecessarily increases, causing wasteful electric power consumption and rising costs. This drawback is the first problem.

Now, the second problem, which relates to a second object of the present invention, will be described referring to Fig. 8 through Fig. 11. Fig. 8 is a block

However, in the prior art, as can be clearly understood referring to Fig. 11, tones that can be displayed become dispersive even after this correction. This point is particularly remarkable in halftones where irregular colors easily become conspicuous, thus the display quality of appearance has been unsatisfactory. This drawback is the second problem.

OBJECTS AND SUMMARY OF THE INVENTION

In view of the first problem, it is a first object of the present invention to provide a display unit which can obtain beautiful display results with a small amount of information and a method therefor.

In view of the second problem, it becomes the second object of the present invention to provide a display unit which can maintain the display quality of the appearance while saving the memory capacity by color reduction and a method therefor.

Briefly stated, the present invention provides a pseudo-tone processing means which color-reduces each RGB component of incoming display data using pseudo-tone processing. A frame memory stores the color-reduced display data before feeding it to a display through a drive means. Color reduction is performed so that the tone number of each RGB component after color reduction is G component > R component > B component. Color reduction is unequally performed in a manner which reflects contributions of each RGB component to brightness.

According to an embodiment of the invention, there is provided a display unit comprising: a display device, a pseudo-tone processing means for receiving inputs of display data, means in the pseudo-tone processing means for color-

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data (red-green), and the plot of triangles represents chromaticity data (blue-yellow).

Contrast sensitivity means the reciprocal number of a contrast threshold. The contrast threshold is a minimum contrast that a human can perceive. The minimum contrast was determined by showing stripes following a sine-wave pattern where the brightness or chromaticity spatially changes (the average brightness or average chromaticity is constant).

In addition, the spatial frequency is a sine-wave pattern frequency that has been converted to an angle of field of a human (deg).

The brightness or the chromaticity shows a downward-sloping tendency where the contrast sensitivity falls as the special frequency increases. At a certain spatial frequency or higher, the contrast sensitivity becomes 1 and it becomes impossible to perceive the stripes. Such a fall occurs at a smaller spatial frequency in chromaticity rather than in the brightness.

In detail, at a spatial frequency on the order of 10 (deg), even if changes (herein, the interval between the stripes: to be exact, the wavelength of a sine wave pattern) exist in chromaticity, humans are deceived into perceiving the chromaticity as uniform. However, humans can still detect changes in brightness.

The human angle of field is an angle created by two line segments which link the viewpoint of an eye with both sides of the object of observation. This is true even when the viewpoint is fixed and the distance between the viewpoint and the object of observation is also fixed. If the ends of the object of observation have different widths, the angle of field results in different values.

As shown in Fig. 3, the angle of field is frequently used in vision tests. In vision tests, a board on which various large and small Landholt rings (each of which forms a C-shape having one gap) are arranged is shown to a subject.

In addition, the contribution to brightness of the G component is in a range of three times to ten times that of the B component. Accordingly, in the present embodiment, the tone number of the G component is set to a range of between three and ten times after color reduction.

However, from the viewpoint of practical use, it is permissible to set the tone number of the G component to a range of between two and 20 times.

The reason that the upper limit may be set as high as "20 times" is that the inventors are aware of an LCD that may require this value. In this LCD, the peak wavelengths of respective light-emitting elements which emit three RGB primary colors are λR=630nm, λG=530nm, and λB=470nm.

CIE-xy chromaticity coordinate values of the respective RGB primary colors are:

in terms of R, (x, y)=(0.707957, 0.292043)

in terms of G, (x, y)=(0.154716, 0.805833)

in terms of B, (x, y)=(0.124142, 0.057814)

The ratio of contributions to brightness of the respective RGB light-emitting elements of this LCD is R:G:B = 5:14:1.

For construction in hardware, it is preferable that each value of the ratio be powers of 2. Using powers of 2 reduces waste in hardware and permits reducing the scale of hardware required.

When taking the above points into consideration, it is desirable to set the tone numbers distributing ratio to R:G:B = 2:4:1. For example, for carrying out a 4,096 color-display by means of color components of 12 bits, it is optimal to set the bit distribution to R=4 bits, G=5 bits, and B=3 bits.

In the above, description of the principle of the present invention is concluded and concrete construction of the display unit according to the present

embodiment is now described with reference to Fig. 1, Fig. 6, and Fig. 7.

In Fig. 1, a pseudo-tone processing means 10 receives inputs of display data (in the present example, each RGB has 6 bits, however, each RGB may have 8 bits.) and color-reduces the data by pseudo-tone processing so that the total number of bits is12, which is sufficient for 4,096 colors. In accordance with the aforementioned principle, the pseudo-tone processing means 10 color-reduces the R component to 4 bits, the G component to 5 bits, and the B component to 3 bits, respectively. The pseudo-tone processing by the pseudo-tone processing means 10 may be either a systematic dither method or an error diffusion method.

A frame memory 11 stores the data after color-deduction output by the pseudo-tone processing means 1. In the present example, similar to Fig. 8 showing the prior art, the frame memory 11 has the capacity to store 12 bits per pixel. Accordingly, electric power consumption and costs are approximately the same as those of the prior art.

However, in accordance with the aforementioned principle, the frame memory 11 stores the R component as 4 bits, the G component as 5 bits, and the B component as 3 bits, respectively, per pixel.

Unlike the prior art, in the present embodiment, as shown in Fig. 1, 12-bit-data of the frame memory 11 is not directly output to a drive means 13. Instead, but the 12- bit-data of the frame memory 11 is corrected to 18- bit-data by a tone correction means 12, located downstream of the frame memory 11. The output of the tone correction means 12 is output to the drive means 13.

In detail, drive means 13 can be an LCD driver LSI, a drive circuit mounted on an LCD substrate, a DA converter circuit for a CRT, a drive circuit for a plasma display or the like.

Tone correction means 12 corrects the R component of 4 bits, the G

art (12 bits per one pixel). However, the data which has been color-reduced by the pseudo-tone processing means 10 is stored in the frame memory 11. The color-reduced data of the frame memory 11 is bit-incremented by the tone correction means 12 and output to the drive means 13.

That is, a series of processes, "from color reduction, storage, bit-increment, correction by the drive means 13 to display" are carried out. Thus, a smoother tone display is attained using the same memory amount as that of the prior art.

As a matter of course, herein, in accordance with the aforementioned principle, the ratio of each RGB component when carrying out color-reduction is provided as:

G component > R component > B component

in line with human visual performance, wherefore a high-quality display which is even easier to view is realized.

The pseudo-tone processing means 10 and the tone correction means 12 in Fig. 1 may be constructed in either the software or hardware. The tone correction means 12 may be omitted. If the tone correction means 12 is omitted, the data inside the frame memory 11 is output to the drive means 13. If the drive means 13 for 6 bits is used for each RGB component as shown in Fig. 1, it is preferable to add dummy data so that each RGB component is 6 bits.

In the present example, the dummy data contains 2 bits for the R component, 1 bit for the G component, and 3 bits for the B component.

Alternatively, in terms of the respective RGB components, it is also possible to use a drive means (unillustrated) corresponding to different bit numbers (R component of 4 bits, G component of 5 bits, and B component of 3 bits).

Application No. (if known): 09/989,593 Attorney Docket No.: 09634/000L266-US0

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